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REPORT OF LABORATORY TESTS. OAK RIDGE NATIONAL LABORATORY SEWAGE. EFFECT OF SETTLING TIME ON SS AND BOD REMOVALS

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REPORT OF LABORATORY TESTS

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OAK RIDGE NATIONAL LABORATORY SEWAGE

EFFECT OF SETTLING TIME ON SS AND BOD REMOVALS

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I. Statement and Purpose

Following the suggestion made by A. E. Gorman, Sanitary Engineer, Atomic Energy Commission, Washington, D. C., and at the request of the Austin Company, laboratory studies were made on the settling characteristics of sewage samples collected throughout a 12-hour period. Samples of sewage, after various periods of quiescent settling, were examined for suspended solids (SS) content and biochemical oxygen demand (BOD) and the removals were noted.

These data supplement material presented in a report by O. R. Placak and C. P. Straub entitled, "Report of Laboratory Tests - Oak Ridge National Laboratory Sewage," dated June 23, 1949.

II. Methods of Sample Collection and Analysis

All samples were collected by representatives of the Austin Company on August 4, 1949 between the hours 6 A.M. and 6 P.M. Hourly samples were collected and iced at manhole (MH) 56 (near manhole 38 used previously) and also at MH 107. At the time of collection, the following items were noted on the tags attached to the gallon sample jugs: MH number, date and time of collection, temperature, flow, and the name or initials of

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the sample collector. Flow measurements were made at two weir boxes, which served the respective sewer lines. These weir boxes measure the flow after passage through septic tanks.

ORNL, Waste Disposal Research Section personnel collected the iced samples at 4-hour intervals, processed the samples, and made the necessary chemical analyses. These included the determination of the pH of the hourly samples and 4-hour composite samples, and the suspended solids and 5-day BOD ($20^{\circ}C$) of the initial and settled composite samples, as well as the initial composite total solids content. The composite samples were proportioned on the basis of the flow data reported at the time of collection.

After compositing, aliquot portions were drawn from the sample for the determination of the initial suspended solids, total solids and 5-day BOD. Of the remaining sample, two liters were added to a 2000 ml graduate and allowed to settle quiescently for a total of 4 hours. Without disturbing the settled material or the floating material, aliquot portions of approximately 400 ml each were removed at the end of 1, 2, 3, and 4 hours. In each instance the sample was siphoned from the container at a point half way between the surface of the liquid and the surface of the settled sludge (Standard Methods for the Examination of Water and Sewage, p. 146). Suspended solids and 5-day BOD determinations were made on each fraction. In all cases, duplicate samples were set up. In the 5-day BOD test, four samples were set up, two of which were for the determination of the initial dissolved oxygen (D.O.) content and the remaining two for the D.O. content at the end of 5 days.

Since a dilution of 10 per cent was used in preparing the D.O. samples for BOD determinations of the first 4-hour composite (representing the period from 6 A.M. to 10 A.M.), these samples were titrated at the end of 2 days rather than at 5 days and the 5-day BOD was computed on the basis of the following formula. (Tabulated values available in reference below [1]).

$$\frac{\text{2-day BOD}}{0.37} \times 0.68 = \text{5-day BOD}$$

A one per cent dilution was used for preparing the remaining 5-day BOD samples. The sodium azide modification of the Winkler method was used in determining the initial and final D.O. content of all samples. Formula "C" water (Standard Methods, P. 140) was used for preparing dilutions.

III. Results of Laboratory Analyses

The data obtained in the present investigation are summarized in a table and 3 figures. Figure 1 shows the relationship between suspended solids reduction and settling time, Figure 2 the relationship between 5-day BOD and the settling time, and Figure 3 shows composite curves for both manholes. Figure 1 and Figure 2 show data for each manhole, and Figure 3 a composite of the other two.

Sewage Characteristics. Table 1 was prepared to show the differences in the two sewages investigated; namely, that for the period June 1-3, and that for August 4. Changes due to reduction in sewage flows

[1] Imhoff and Fair, Sewage Treatment, John Wiley and Sons, Inc., New York, 1940, page 39, Table 4.

are noted. These data show that there were substantial decreases in the volume of flow reported for August 4 as compared with data presented for the daylight hours on June 1-3 (84.6 gpm to 61.4 for MH 38-56 and 85.5 to 30.2 for MH 107, respectively).

Slight changes in the temperature and pH are also noted. Increases in the concentrations of suspended solids and BOD are indicated; namely, 83 to 94 ppm for SS at MH 38-56, 81.5 to 102 ppm for SS at MH 107, 105 to 115 ppm for BOD at MH 38-56, and 79.5 to 89 ppm for BOD at MH 107.

Effect of Settling Time. As stated previously, samples were taken at intervals from 2 liter graduated cylinders and the SS and 5-day BOD were determined. The reductions obtained are plotted on the attached curves and a composite curve was computed from these data. The curves for MH 56 show that 30 per cent removal of the SS could be expected at the end of 1 hour, 40 per cent at the end of 2 hours, and an increase of 6 per cent with an additional 2 hours detention (from 2 to 4 hours). For MH 107, the data are comparable: 27 per cent removal of the SS in 1 hour, 38 per cent in 2 hours, 44 per cent in 3 hours, and 46 per cent in 4 hours, or an increase of 8 per cent with the additional 2 hours detention.

For the curves which show reduction in BOD with settling time, the values were as follows: With 1 hour of settling, the BOD was reduced only 7 per cent; with 2 hours, 13 per cent; with 3 hours, 18 per cent; and with 4 hours, 22 per cent for MH 56 or an increase of 9 per cent with 2 hours additional settling; for MH 107, with 1 hour settling, the reduction in BOD amounted to 14 per cent; with 2 hours, 21 per cent; with 3 hours,

25 per cent, and with 4 hours, 27 per cent or an increase of 6 per cent with 2 hours additional settling.

A third set of curves was prepared in which the values obtained for MH 56 and 107 were combined (on the basis of flows) and simple composite curves were drawn for SS and BOD removals versus settling time. These curves show that with 2-hour detention time the removals in SS and BOD were 37 per cent and 14 per cent, respectively, and with 4-hour detention time these values were 44 and 22 per cent, respectively, which indicates a 7 and 8 per cent increase in SS and BOD, respectively, for 2 hours additional settling time.

IV. Discussion

The individual points, which represent the results of tests made on 4-hour composite samples show wide variations. This is not unusual when the great variability of sewage concentration and flow are taken into consideration. To define the settling curves more accurately a large number of analyses should be made using a range of sewage concentrations. The net result of such a study would be a set of curves similar to the type published by Norman C. Wittwer (Sewage Works Journal, Vol. 12, pp. 521-524, May, 1940) for the Rahway Valley Sewage Treatment Plant. Similar curves showing the effect of concentration of sewage have been prepared by Schroepfer for both the suspended solids and BOD (Sewage Works Journal, Vol. 5, p. 209, March, 1933).

Several other factors should be considered when the data reported herein are translated for use in design: (1) the results were obtained

under conditions of quiescent settling without interference from velocity or wind currents, (2) the sewage was very fresh and not disintegrated and the larger particles would settle more rapidly. These factors would tend to increase the reduction obtained in the laboratory tests.

In addition, the tentative design plans call for pumping the sewage from the east line (MH 107) through a force main to permit treatment of all the sewage at one point, and for comminution of the sewage before sedimentation. In passing through the pumps and force main some comminution of the sewage may take place and all sewage will be comminuted at the sewage treatment plant. Comminution may decrease the settling rate of the sewage. Further, if the sewage in the east line flows into a wet well, and will be pumped from there when a certain level is reached, some of the sewage may be stored for some time, and possibly septicity may result, particularly since the flows are relatively low. This condition would be modified by rather frequent pumping of the wet well.

The data presented for the removal of suspended solids and BOD show lower removals than those reported in the literature for an <u>average domestic</u> sewage which are about 15-20 per cent higher. (Imhoff and Fair, Sewage Treatment, John Wiley and Sons, Inc., 1940, p. 64). No data are available on industrial or factory sanitary sewage flows.

V. <u>Conclusions</u>

The following conclusions may be drawn from the study made on the reduction in suspended solids and BOD due to settling for varying intervals of time and from the new flow determinations.

1. There has been a marked reduction in the sewage flow since the first study was made June 1-3, 1949, particularly in the east line served by MH 107.
2. There has been some increase in the suspended solids and BOD concentrations of the sewage, due no doubt, to the decrease in sewage flow.
3. An increase in detention time from 2 to 4 hours indicates an additional removal of about 7 per cent in the suspended solids and about 8 per cent in the 5-day BOD.
4. These data do not indicate any appreciable advantage in increasing the detention time from 2 to 4 hours. Since the object of primary sedimentation is to keep floating solids and some of the suspended solids from entering the receiving stream, it is felt that these objectives could be obtained with 2 hours settling time.
5. A well designed primary settling basin with 2 hours detention time should be sufficient and satisfactory for the volume and concentration of sewage encountered at present at ORNL.

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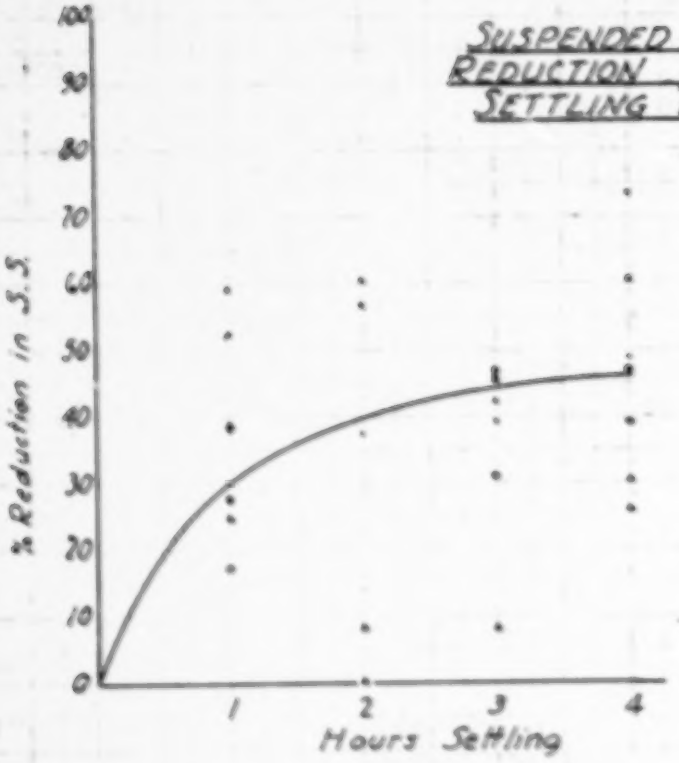
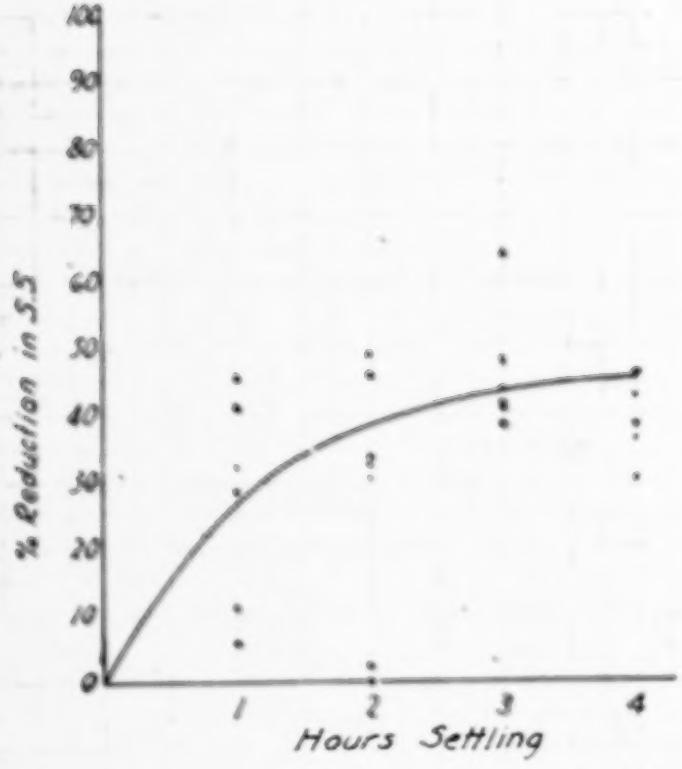
SUSPENDED SOLIDS REDUCTION versus SETTLING TIME



MH 56

Wt. Av. 6am-6pm - 94.1 ppm.

Samples Collected
Aug. 4, 1949



MH 107

Wt. Av. 6am-6pm - 102.3 ppm

Legend:
- Wt. Av. Values
- Removals for Samples collected 6am-10am
- Removals for Samples collected 10am-2pm
- Removals for Samples collected 2pm-6pm

C.P.S. 8/10/49

Figure 1

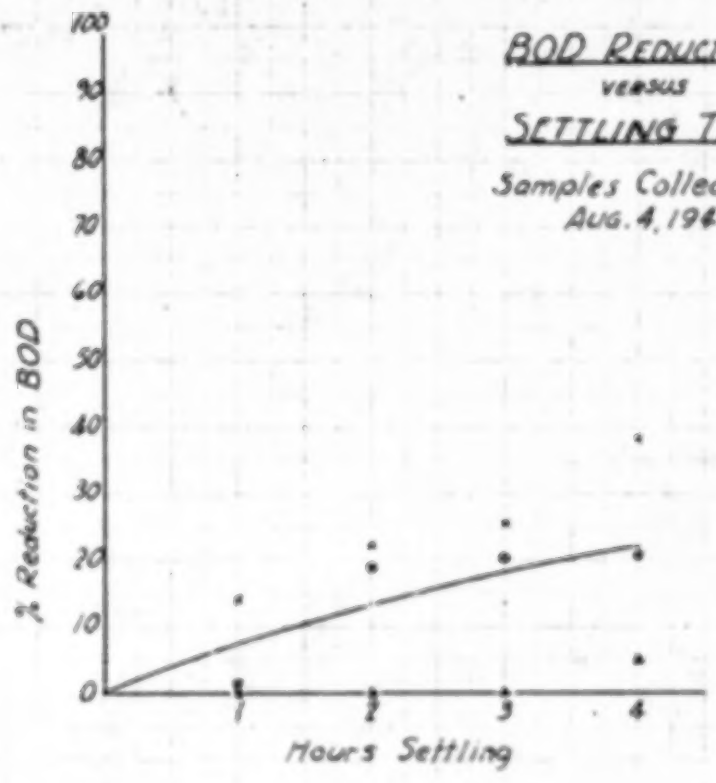
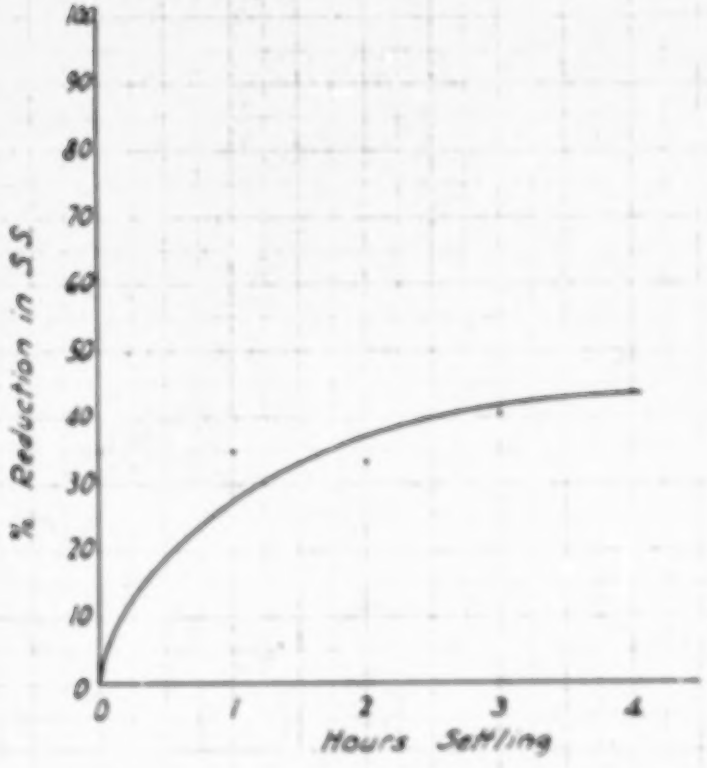

BOD Reduction
versus
Settling Time
Samples Collected
Aug. 4, 1949
MH 56
Wt. Av. 6am-6pm - 115 ppm
% Reduction in BOD
Hours Settling
MH 107
Wt. Av. 6am 6pm - 89.2 ppm
Legend
• Weighted Average Values
• Removals for samples collected 6am-10am.
• Removals for samples collected 10am-2pm
• Removals for samples collected 2pm-6p.m.
C.P.S. 8-10-49

Figure 2

ORNL Sewage
MH 56 & 107
Collected Aug 4 1969

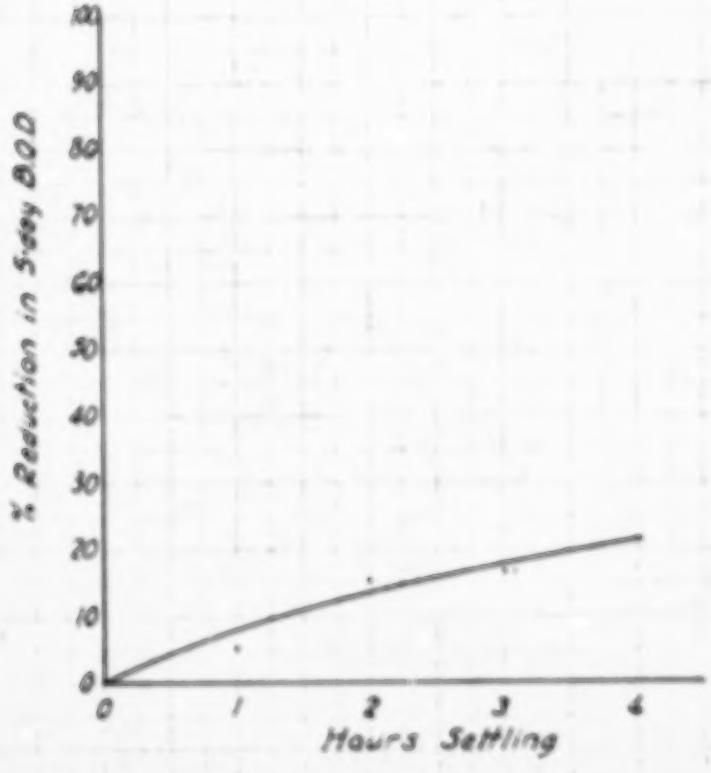
Suspended Solids
Reduction versus
Settling Time

Initial SS Content 97ppm.



BOD Reduction
versus
Settling Time

Initial BOD Content 107ppm



C.P.S. 8-4-69

Figure 3

Table 1

Characteristics of CSSL Sewage

DATE	SAMPLE LOCATION	TIME OF SAMPLING	FLOW mgm	TEMP. °C	pH	TOTAL SOLIDS-p.p.m.			SUSPENDED SOLIDS p.p.m.			DISSOLVED SOLIDS p.p.m.			5-DAY BOD
						Total	Volatile	Ash	Total	Volatile	Ash	Total	Volatile	Ash	
June 1-2	12H 38	8:00AM-8:30AM	77.8	24.9	7.4-8.1	280.	135.	146.	64.	42.	22.	216.	93.	124.	57.
	12H 107	8:30AM-8:45AM	54.4	22.7	7.2-7.9	253.	121.	132.	50.	42.	8.	203.	79.	124.	53.
June 1-2	12H 38	7:00AM-6:00PM	64.0	23.9	7.4-7.8	304.	125.	179.	73.	48.	25.	291.	137.	154.	84.
2-3	12H 38	7:30AM-6:30PM	65.2	24.4	7.6-8.0	356.	219.	137.	103.	98.	5.	253.	121.	132.	125.
June 1-2	12H 107	7:15AM-6:15PM	60.6	24.4	7.2-7.8	307.	178.	129.	94.	80.	14.	213.	98.	115.	89.
2-3	12H 107	7:45AM-6:45PM	110.4	23.3	7.2-7.8	315.	132.	183.	69.	60.	9.	246.	72.	174.	70.
Aug. 4	12H 56*	8:00AM-6:00PM	61.4	32.8	7.3-8.0	403.	241.	162.	94.	74.	20.	309.	167.	142.	115.
	12H 107	8:00AM-6:00PM	30.2	27.1	7.3-7.9	362.	204.	158.	102.	70.	33.	260.	134.	125.	89.

*12H 56 is located near and replaces 12H 38.